WHAT IS CLAIMED IS:

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1. A method for nuclear magnetic resonance imaging of an investigation region of formation surrounding a wellbore, comprising the steps of:

applying a series of magnetic field gradients to phase encode nuclei spins within the investigation region, wherein the strength of the magnetic field gradient applied is different from at least one previously applied magnetic field gradient within the series; and

detecting nuclear magnetic resonance signals from the investigation region resulting from the series of magnetic field gradients.

2. The method of claim 1, further comprising the step of mapping the signals to one or more angular segment of the formation around the wellbore.

3. The method of claim 1, further comprising the step of mapping the signals to one or more radial segment of the formation around the wellbore.

4. The method of claim 1, further comprising the step of mapping the signals to one or more axial segment of the formation around the wellbore.

5. The method of claim 1, further comprising the step of applying a static magnetic field circumferentially around the wellbore and into the investigation region.

6. The method of claim 1, further comprising the step of applying a RF magnetic field circumferentially around the wellbore and into the investigation region.

7. The method of claim 1, wherein the series of magnetic field gradients are oriented circumferentially into the investigation region relative to the wellbore.

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8. The method of claim 1, wherein the series of magnetic field gradients are oriented radially into the investigation region relative to the wellbore.

9. The method of claim 1, wherein the series of magnetic field gradients are oriented axially into the investigation region relative to the wellbore.

10. The method of claim 1, further comprising the step of inducing a plurality of spin-echo signals from selected nuclei in the investigation region of the formation.

11. The method of claim 10, further comprising the step of canceling the applied magnetic field gradient prior to applying a magnetic field gradient for the next spin-echo signal.

12. The method of claim 1, further comprising the step of generating a sequence of pulses and spin-echoes that provides an azimuthally resolved image of a portion of the formation.

13. The method of claim 1, further comprising the step of generating a sequence of pulses and spin-echoes that provides a radially resolved image of a portion of the formation.

14. The method of claim 1, further comprising the step of generating a sequence of pulses and spin-echoes that provides an axially resolved image of a portion of the formation.

15. The method of claim 12, wherein during a single pulse sequence, the step of generating a sequence of pulses and spin-echoes comprises the steps of:

i) during a first time period, applying a first RF pulse and a first gradient pulse in the investigation region and measuring the generated signals in the investigation region;

ii) canceling the first gradient pulse;

iii) during a second time period, applying a second RF pulse and a second gradient pulse in the investigation region and measuring the generated signals in the investigation region, wherein the second gradient pulse has an amplitude that is incremented from the first gradient pulse.

16. The method of claim 1, further comprising the steps of generating a first pulse sequence comprising a plurality of phase alternated RF pulses, a first set of incremented phase altering gradient pulses and a first set of spin-echoes and generating a second pulse sequence comprising a plurality of phase alternated RF pulses, a second set of incremented phase altering gradient pulses, and a second set of spin-echoes.

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17. The method of claim 16, wherein the first set of incremented phase altering gradient pulses is generated from a first gradient coil and the second set of incremented phase altering gradient pulses is generated from a second gradient coil, wherein the second gradient coil is angularly spaced from the first gradient coil within the wellbore, defining a gradient coil phase angle.

18. The method of claim 17, wherein the image of the formation mapped from the nuclear magnetic resonance signals from the investigation region has an azimuthal resolution substantially equal to the gradient coil phase angle.

19. The method of claim 1, further comprising the step of processing the detected nuclear magnetic resonance signals to optimize the formation image.

20. The method of claim 1, further comprising the step of detecting the nuclear magnetic resonance signals while drilling into the formation.

21. The method of claim 1, further comprising the steps of detecting the detected nuclear magnetic resonance signals, and partitioning the detected signals into a plurality of bins.

22. The method of claim 21, further comprising the step of partitioning a cross-section of the formation into a plurality of angular distance segments wherein each bin represents the measured signals from at least one of the angular distance segments.

23. The method of claim 1, further comprising the steps of solving a series of Fourier transforms of the detected nuclear magnetic resonance signals, and partitioning the Fourier transforms into a plurality of bins.

24. The method of claim 23, further comprising the step of partitioning a cross-section of the formation into a plurality of angular distance segments, wherein each bin represents the measured signals from at least one of the angular distance segments.

25. The method of claim 24, wherein the strength of the magnetic field gradient of greatest amplitude is chosen so that, when the magnetic field gradient is applied, it is at least strong enough to induce a phase difference between adjacent angular distance segments of at least 180 degrees.

26. The method of claim 23, further comprising the step of partitioning a portion of the formation into a plurality of radial distance segments, wherein each bin represents the measured signals from at least one of the radial distance segments.

27. The method of claim 23, further comprising the step of partitioning a portion of the formation into a plurality of axial distance segments, wherein each bin represents the measured signals from at least one of the axial distance segments.

28. The method of claim 1, further comprising the steps of providing a plurality of gradient means positioned around the circumference of a logging device and selecting at least one of the gradient means to apply the magnetic field gradient to the formation.

29. The method of claim 28, further comprising the simultaneous application of gradient pulses from two or more gradient means to phase encode nuclei spins within the investigation region.

30. The method of claim 29, further comprising controlling the amplitudes of the two or more gradient means to produce a cumulative gradient pulse effect, and defining an equivalent gradient coil phase angle.

31. The method of claim 30, further comprising the steps of solving at least one Fourier transform of the detected nuclear magnetic resonance signals, and partitioning the at least one Fourier transform solution into a plurality of bins.

32. The method of claim 31, further comprising the step of partitioning a cross-section of the formation into a plurality of angular distance segments, wherein each bin represents the measured signals from at least one of the angular distance segments.

33. The method of claim 1, further comprising the step of azimuthally changing the phase of nuclei spins within the investigation region.

34. The method of claim 1, further comprising the step of radially changing the phase of nuclei spins within the investigation region.

35. The method of claim 1, further comprising the step of axially changing the phase of nuclei spins within the investigation region.

36. A method for measuring a nuclear magnetic resonance property in an investigation region of earth formations surrounding a wellbore, comprising the steps of:

a) drilling a wellbore in the formation with a logging-while-drilling device;

b) measuring the nuclear magnetic resonance properties of at least one formation while drilling the wellbore, comprising the steps of:

i) applying a static magnetic field circumferentially around the wellbore and into the investigation region as the logging device moves within the wellbore;

ii) applying an RF magnetic field circumferentially around the wellbore and into the investigation region as the logging device moves within the wellbore;

iii) inducing a plurality of spin-echo signals from selected nuclei of the formation;

iv) applying a series of magnetic field gradients to phase encode spins within the investigation region, the strength of the magnetic field gradient applied for each spin-echo signal is different from previously applied magnetic field gradients within the series; and

v) detecting nuclear magnetic resonance signals from the investigation region.

37. The method of claim 36, further comprising the step of generating a first pulse sequence comprising a plurality of phase alternated RF pulses and spin-echoes and a first series of magnetic field gradients, and generating a second pulse sequence comprising a plurality of phase alternated RF pulses and spin-echoes and a second series of magnetic field gradients.

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38. The method of claim 36, wherein during a single pulse sequence, the step of generating a sequence of pulses and spin-echoes comprises the steps of:

i) during a first time period, applying a first RF pulse and a first gradient pulse in the investigation region and measuring the generated signals in the investigation region;

ii) canceling the first gradient pulse;

iii) during a second time period, applying a second RF pulse and a second gradient pulse in the investigation region and measuring the generated signals in the investigation region, wherein the second gradient pulse has an amplitude that is different from the first gradient pulse.

39. The method of claim 38, wherein the step of generating a pulse sequence further comprises the step of applying a fixed wait time between applying the RF pulse and the gradient pulse.

40. The method of claim 38, wherein the step of generating a pulse sequence further comprises the step of applying a variable wait time between applying the RF pulse and the gradient pulse.

41. The method of claim 36, further comprising the simultaneous application of gradient pulses from two or more gradient means to diphase nuclei spins within the investigation region.

42. The method of claim 41, further comprising controlling the amplitudes of the two or more gradient means to produce a cumulative gradient pulse effect.

43. The method of claim 42, further comprising the steps of solving a series of Fourier transforms of the detected nuclear magnetic resonance signals, and partitioning the Fourier transforms into a plurality of bins.

44. The method of claim 43, further comprising the step of partitioning a cross-section of the formation into a plurality of angular distance segments, wherein the content of each bin represents the measured signals from at least one of the angular distance segments.

45. The method of claim 44, further comprising the step of mapping the measured signals to one or more angular segment of the formation around the wellbore.

46. The method of claim 45, wherein the strength of the magnetic field gradient of greatest amplitude is chosen so that, when the magnetic field gradient is applied, it is at least strong enough to induce a phase difference between adjacent angular distance segments of at least 180 degrees.

47. The method of claim 43, further comprising the step of partitioning a section of the formation into a plurality of radially segmented formation sections, wherein the content of each bin represents the measured signals from at least one of the radially segmented formation sections.

48. The method of claim 47, further comprising the step of mapping the measured signals to one or more radially segmented formation sections of the wellbore.

49. The method of claim 43, further comprising the step of partitioning a section of the formation into a plurality of axial distance segments, wherein the content of each bin represents the measured signals from at least one of the axial distance segments.

50. The method of claim 49, further comprising the step of mapping the measured signals to one or more axial distance segments of the wellbore.

51. A method for measuring a nuclear magnetic resonance property in an investigation region of earth formations surrounding a borehole, comprising the steps of:

a) positioning a logging device in the borehole;

b) measuring the nuclear magnetic resonance properties in the investigation region, comprising the steps of:

i) applying a static magnetic field circumferentially around the borehole and into the investigation region;

ii) applying an RF magnetic field circumferentially around the borehole;

iii) inducing a plurality of spin-echo signals from selected nuclei of the formation;

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iv) applying a series of magnetic field gradients to phase encode spins in a portion of the investigation region wherein the strength of the magnetic field gradient applied for each spin-echo signal is altered from previously applied magnetic field gradients within the series; and

v) detecting nuclear magnetic resonance signals from the investigation region;

c) analyzing the nuclear magnetic resonance signals utilizing Fourier transform analysis;

d) partitioning the Fourier transform analysis results into a plurality of bins;

e) partitioning a cross-section of the formation into a plurality of angular distance segments, wherein each bin represents the measured signals from at least one of the angular distance segments; and

f) mapping the signals from at least one bin to at least one angular segment of the formation around the wellbore.

52. The method of claim 51, further comprising the step of azimuthally changing the phase of nuclei spins within the investigation region.

53. The method of claim 51, further comprising the step of radially changing the phase of nuclei spins within the investigation region.

54. The method of claim 51, further comprising the step of axially changing the phase of nuclei spins within the investigation region.

55. The method of claim 51, wherein the strength of the magnetic field gradient of greatest amplitude is chosen so that, when the magnetic field gradient is applied, it is at least strong enough to induce a phase difference between adjacent angular segments of at least 180 degrees.

56. The method of claim 55, further comprising the simultaneous application of magnetic field gradient pulses from two or more gradient means to phase encode nuclei spins within the investigation region.

57. The method of claim 56, further comprising controlling the amplitudes of the two or more gradient means to produce a cumulative gradient pulse effect, and thereby defining an equivalent gradient coil phase angle.

58. A method for measuring a nuclear magnetic resonance property in an investigation region of earth formations surrounding a borehole, comprising the steps of:

a) positioning a logging device in the borehole;

b) measuring the nuclear magnetic resonance properties in the investigation region, comprising the steps of:

i) applying a static magnetic field circumferentially around the borehole and into the investigation region;

ii) applying an RF magnetic field circumferentially around the borehole;

iii) inducing a plurality of spin-echo signals from selected nuclei of the formation;

iv) applying a series of magnetic field gradients to phase encode spins in a portion of the investigation region wherein the strength of the magnetic field gradient applied for each spin-echo signal is altered from previously applied magnetic field gradients within the series; and

v) detecting nuclear magnetic resonance signals from the investigation region;

c) analyzing the nuclear magnetic resonance signals utilizing Fourier transform analysis;

d) partitioning the Fourier transform analysis results into a plurality of bins;

e) partitioning a cross-section of the formation into a plurality of radial distance segments, wherein each bin represents the measured signals from at least one of the radial distance segments; and

f) mapping the signals from at least one bin to at least one radial segment of the formation around the wellbore.

59. A method for measuring a nuclear magnetic resonance property in an investigation region of earth formations surrounding a borehole, comprising the steps of:

a) positioning a logging device in the borehole;

b) measuring the nuclear magnetic resonance properties in the investigation region, comprising the steps of:

   i) applying a static magnetic field circumferentially around the borehole and into the investigation region;

   ii) applying an RF magnetic field circumferentially around the borehole;

   iii) inducing a plurality of spin-echo signals from selected nuclei of the formation;

   iv) applying a series of magnetic field gradients to phase encode spins in a portion of the investigation region wherein the strength of the magnetic field gradient applied for each spin-echo signal is altered from previously applied magnetic field gradients within the series; and

   v) detecting nuclear magnetic resonance signals from the investigation region;

c) analyzing the nuclear magnetic resonance signals utilizing Fourier transform analysis;

d) partitioning the Fourier transform analysis results into a plurality of bins;

e) partitioning a cross-section of the formation into a plurality of axial distance segments, wherein each bin represents the measured signals from at least one of the axial distance segments; and

f) mapping the signals from at least one bin to at least one axial segment of the formation around the wellbore.

60. An apparatus for determining a nuclear magnetic resonance property in an investigation region of earth formations surrounding a wellbore, comprising:

a) a logging device moveable through the wellbore;

b) means in the logging device for applying a static magnetic field circumferentially around the wellbore and into the investigation region;

c) antenna means in the logging device for applying an RF magnetic field circumferentially around the borehole and into the investigation region, whereby the antenna means induces a plurality of pulse echoes and spin-echo signals from selected nuclei of the formation;

d) at least one gradient means in the logging device capable of producing a gradient magnetic field within the borehole and into the investigation region and capable of producing different strength gradient magnetic fields for each of the plurality of pulse echoes, wherein the orientation of the gradient magnetic field and the static magnetic field effects on the selected nuclei vary depending on the azimuthal position around the wellbore in relation to the gradient means; and

e) means for detecting nuclear magnetic resonance signals from the investigation region.

61. The apparatus of claim 60, further comprising means for generating a sequence of pulses and spin-echoes that provides an azimuthally resolved nuclear magnetic resonance measurement.

62. The apparatus of claim 60, further comprising means for generating a first pulse sequence comprising a plurality of phase alternated RF pulses and spin-echoes and means for generating a second pulse sequence comprising a plurality of phase alternated RF pulses, at least one gradient pulse, and spin-echoes.

63. The apparatus of claim 60, further comprising means for generating a sequence of pulses and spin-echoes that provide an azimuthally resolved nuclear magnetic resonance measurement.

64. The apparatus of claim 60, wherein the at least one gradient means comprises two gradient coils positioned approximately perpendicular to each other.

65. The apparatus of claim 60, wherein each gradient coil is capable of producing a variable strength gradient magnetic field into the investigation region.

66. An apparatus for determining a nuclear magnetic resonance property in an investigation region of earth formations surrounding a wellbore, comprising:

a) a logging device moveable through the wellbore;

b) means in the logging device for applying a static magnetic field circumferentially around the wellbore and into the investigation region;

c) antenna means in the logging device for applying an RF magnetic field circumferentially around the borehole and into the investigation region, whereby the antenna means induces a plurality of pulse echoes and spin-echo signals from selected nuclei of the formation;

d) at least one gradient means in the logging device capable of producing a gradient magnetic field within the borehole and into the investigation region and capable of producing different strength gradient magnetic fields for each of the plurality of pulse echoes, wherein the orientation of the gradient magnetic field and the static magnetic field effects on the selected nuclei vary depending on the radial position within the formation in relation to the gradient means; and

e) means for detecting nuclear magnetic resonance signals from the investigation region.

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67. The apparatus of claim 66, further comprising means for generating a sequence of pulses and spin-echoes that provides a radially resolved nuclear magnetic resonance measurement.

68. The apparatus of claim 66, further comprising means for generating a sequence of pulses and spin-echoes that provide a radially resolved nuclear magnetic resonance measurement.

69. An apparatus for determining a nuclear magnetic resonance property in an investigation region of earth formations surrounding a wellbore, comprising:

a) a logging device moveable through the wellbore;

b) means in the logging device for applying a static magnetic field circumferentially around the wellbore and into the investigation region;

c) antenna means in the logging device for applying an RF magnetic field circumferentially around the borehole and into the investigation region, whereby the antenna means induces a plurality of pulse echoes and spin-echo signals from selected nuclei of the formation;

d) at least one gradient means in the logging device capable of producing a gradient magnetic field within the borehole and into the investigation region and capable of producing different strength gradient magnetic fields for each of the plurality of pulse echoes, wherein the orientation of the gradient magnetic field and the static magnetic field effects on the selected nuclei vary depending on the axial position within the wellbore in relation to the gradient means; and

e) means for detecting nuclear magnetic resonance signals from the investigation region.

70. The apparatus of claim 69, further comprising means for generating a sequence of pulses and spin-echoes that provides an axially resolved nuclear magnetic resonance measurement.

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71. The apparatus of claim 69, further comprising means for generating a sequence of pulses and spin-echoes that provide an axially resolved nuclear magnetic resonance measurement.

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72. An apparatus for determining a nuclear magnetic resonance property in an investigation region of earth formations surrounding a wellbore, comprising:

a) a logging device moveable through the wellbore;

b) magnets within the logging device for applying a static magnetic field circumferentially around the wellbore and into the investigation region;

c) at least one antenna in the logging device for applying an RF magnetic field circumferentially around the borehole and into the investigation region, whereby the one or more antenna is capable of inducing a plurality of pulse echoes and spin-echo signals from selected nuclei of the formation;

d) one or more gradient coils within the logging device capable of producing a gradient magnetic field circumferentially around the borehole and into the investigation region, the gradient coils adapted to produce incrementally different strength gradient magnetic fields for each of the plurality of pulse echoes, wherein the orientation of the gradient magnetic field and the static magnetic field effects on the selected nuclei vary depending on the asimuthal position around the wellbore in relation to the gradient means; and

e) one or more antenna for detecting nuclear magnetic resonance signals from the investigation region.

73. The apparatus of claim 72, wherein the gradient coil is capable of applying a magnetic field gradient having a strength great enough to induce a phase difference of at least 180 degrees between adjacent angular distance segments in the formation.

74. The apparatus of claim 73, comprising two or more gradient coils capable of simultaneous application of magnetic field gradient pulses from two or more gradient coils to phase encode nuclei spins within the investigation region.

75. The apparatus of claim 74, wherein the two or more gradient coils are adapted to enable variable amplitudes of the magnetic field gradient pulses from the two or more gradient coils to produce a cumulative magnetic field gradient pulse effect, thereby defining an equivalent gradient coil phase angle.

76. The apparatus of claim 75, wherein the apparatus comprises two gradient coils located perpendicular to each other.